

SHIP PRODUCTION COMMITTEE  
FACILITIES AND ENVIRONMENTAL EFFECTS  
SURFACE PREPARATION AND COATINGS  
DESIGN/PRODUCTION INTEGRATION  
HUMAN RESOURCE INNOVATION  
MARINE INDUSTRY STANDARDS  
WELDING  
INDUSTRIAL ENGINEERING  
EDUCATION AND TRAINING

June 1976  
NSRP 0002

# **THE NATIONAL SHIPBUILDING RESEARCH PROGRAM**

## **Proceedings of the REAPS Technical Symposium**

### **Paper No. 6: SPADES System Current Developments**

U.S. DEPARTMENT OF THE NAVY  
CARDEROCK DIVISION,  
NAVAL SURFACE WARFARE CENTER

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**E**ngineering for  
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## SPADES SYSTEM CURRENT DEVELOPMENTS

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Mr. Schulze has ten years of experience in applying electronic data processing techniques to shipbuilding. At Cali and Associates he is responsible for developing new software in this area.

For enhancement of the 'SPADES' System, three new modules are currently planned and under development:

1. Ship Production and Control Module (SPAC). A management information system which utilizes the information collected on the 'SPADES' data base.
2. Detail Engineering Module (DEMO). A module that is designed not only to produce engineering drawings, but to aid in data collection and consequent loading of the data base with information generated by the Engineering Department.
3. Pipe Length and End-Cuts Program (PLEC). A special program to aid in fabrication of complex three-dimensional pipe structures, which is of special interest to manufacturers of oil rig structures.

Like all other modules of 'SPADES', these new modules will directly access the 'SPADES' data base, utilizing information that has been generated by other modules, and in turn making available to the other modules information gathered by it. Thus, information is collected and stored where it is generated. There will be no need to recreate information by other departments downstream with the duplication of effort and a high probability of errors. The three new modules will continue the expansion of 'SPADES' from an N/C manufacturing method to a computer-controlled information flow throughout the entire design and construction period.

# " S P A D E S ' S Y S T E M

## SHIP PRODUCTION & CONTROL MODULE

{Preliminary Description}

### INTRODUCTION

The use of extensive modular construction in shipbuilding, combined with the increased use of Numerical Control, has greatly improved in the last decade the efficiency of the industry.

In order to properly utilize these techniques, it was immediately apparent, however, that more and better planning was necessary.

The planning effort, per se, is neither too difficult nor too costly. The collection and updating of the data needed to generate the required reports is both difficult and costly in order to obtain a reasonable degree of accuracy.

The 'Ship Production and Control (SPAC) Module' of the 'SPADES' System is designed to achieve in this area the following goals:

1. Reduce man-hours for data collection.
2. Improve the accuracy and timeliness of the reports.
3. Reduce ship construction costs by reducing errors and misinformation in the shops.

The 'SPAC' Module covers at the present only the hull construction. It is intended that, in parallel with the development of modules to handle the design and production of other ships' systems, the 'SPAC' Module will be expanded accordingly.

## DESIGN CRITERIA OF THE 'SPAC' MODULE

Since the 'SPAC' Module properly falls in the category of management information systems, the basic criteria applicable to this type of system must be respected as follows:

1. The module must allow the collection of independent data at the origination source and make it immediately available to all interested shipyard functions.

As an example, for instance, assembly boundaries and schedule starts can be inputted directly to the system and the 'master erection schedule' report generated immediately after for dissemination.

2. All applicable data generated by other modules of 'SPADES' must be collected and used by the 'SPAC' Module without any user intervention.

This feature is the main justification for the development of the module, and the following is a partial list of examples:

1 Allocation to the proper assembly and sub-assembly of all pieces generated through use of 'PARTGEN', 'PARTSEP', 'PLATDV', or MANF AID' (frame bending).

- Processing time for N/C burning tapes and flame planer sketches.

ŽUnit weight of individual pieces and weight and centers of gravity of assemblies and sub-assemblies.

- Length and nesting within standard lengths of shapes of the various individual shape pieces.

ŽCross reference between assemblies due to the nesting into a plate of pieces belonging to different assemblies.

ŽBulk material allocation for pieces produced through shearing or 'one-to-one' optical burning.



3. Revision control is maintained by the system for all the issued reports generated.

A summary report can also be generated, showing at any one point in time the current valid revisions of all the issued reports.

4. Any change of the independent data or other data used by the system must generate an exception report indicating which of the reports are affected by the change, so that the user can initiate the proper request.

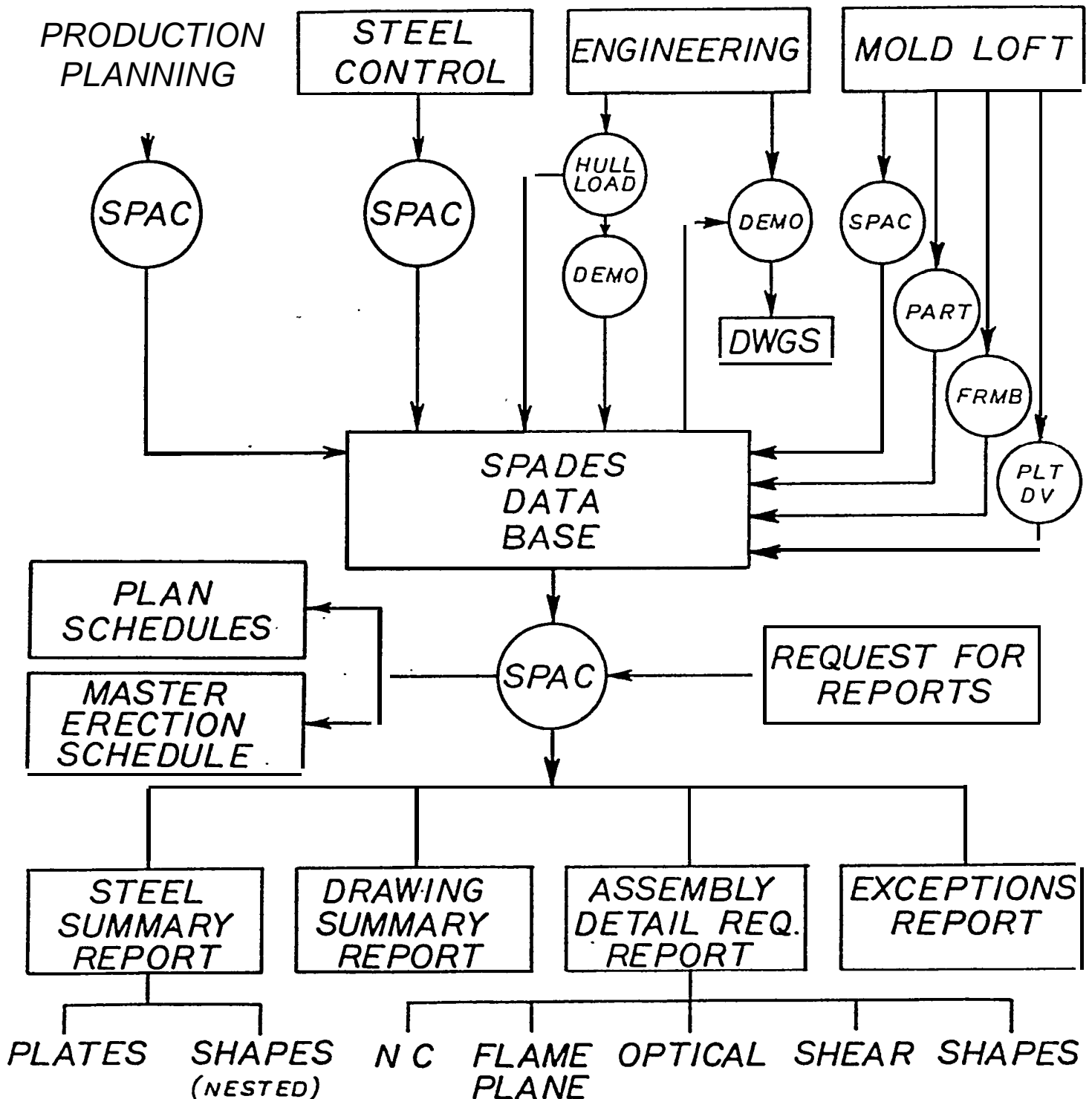
For example, if planning changes require different boundaries for any one assembly, the module must automatically update the allocation of all pieces effected by the change of boundaries, and give a report indicating which reports must be requested for re-issue.

5. Exception reports can be generated to indicate to the user at any point in time which pieces for any one particular drawing have not as yet been defined, or any material deficiencies.
6. The system must allow the introduction of data at levels other than the optimum, to override or enrich the data base, in order to be able to generate complete reports at any time.

The following pages contain the basic data flow for the module, a brief description of the input needed, and some examples of the reports generated by the system. The examples of the reports are simulated in this preliminary description, and they will be changed as the development of the module proceeds.

# SPADES SYSTEM

## DATA FLOW FOR SHIP PRODUCTION AND CONTROL MODUL



TYPES OF INPUT & RESPONSIBILITY FOR  
THEIR PREPARATION BY SHIPYARD FUNCTION

1. Production Planning

- a) Limiting boundaries of planned assemblies (units) and sub-assembly breakdown, if any. The system will always assume that a ship's surface, such as deck, webs or shell will constitute a sub-assembly.
- b) Planned start date for processing each assembly.

2. Steel Control

- a) Final steel bill. This is intended to mean the steel take-off bill as modified for utilization of stock and/or standardization of plate size. The various items in the various steel bills will carry a unique stock number compatible with the shipyard system.
- b) Storage location of various items in the steel bill will be given to the system upon receipt of the steel.

3. Engineering

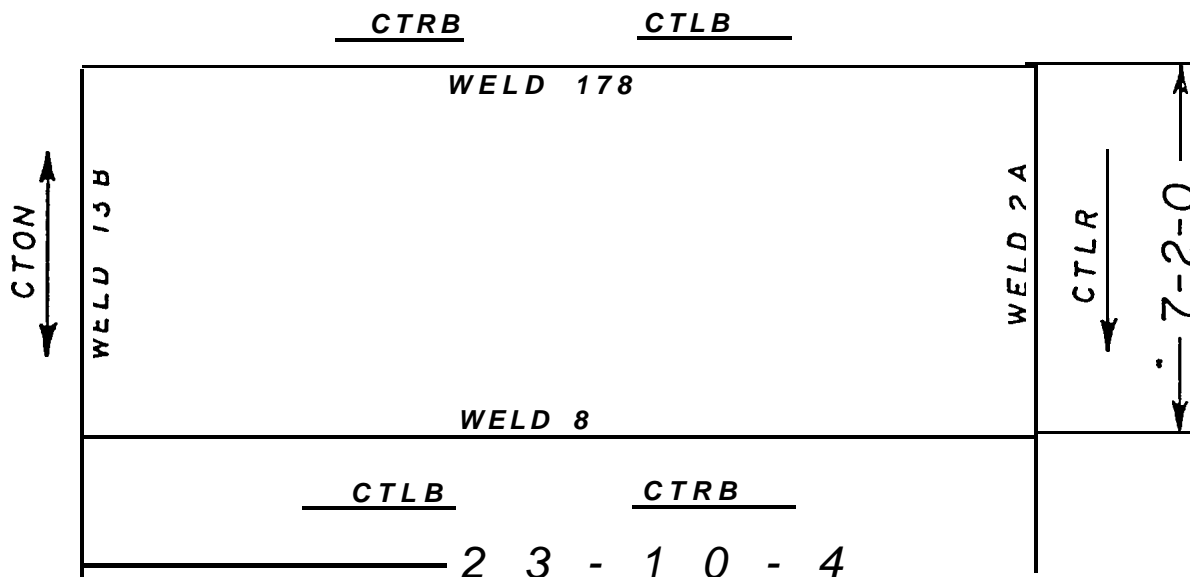
- a) Loading of the data base. Through the detail engineering module, the data base loading capabilities will be expanded, allowing at the same time the easy generation of detail drawings. As part of this activity, engineering will also update, as needed, data base libraries of standards (brackets, chocks, etc. ), shapes, characteristics, and associated cut-outs.
- b) Drawing list and associated range of pc. mks. used in each drawing. This will allow the system to generate exception reports calling attention to pieces not generated at any one point in time.

4. Mold Loft

- a) Through the use of 'PARTGEN', 'PARTSEP' and 'PLATDV', the loft will enable the system to allocate the pieces thusly generated to the various assemblies and sub-assemblies. Provision will be made for identifying drawings, pc. mk. and beveling detail, and also applicability of a part to another area of the ship.

SHIPYARD NAME  
EXACTOGRAPH SKETCH

SHIP \_\_\_\_\_ HULL NO. \_\_\_\_\_  
JOB ORDER NO. \_\_\_\_\_  
ASSEMBLY \_\_\_\_\_  
SUB ASSEMBLY \_\_\_\_\_  
DWG. NO. \_\_\_\_\_ PC. NO. \_\_\_\_\_ DET NO. \_\_\_\_\_  
PLATE SIZE \_\_\_\_\_ QTY REQD. \_\_\_\_\_  
PLATE STOCK NO. \_\_\_\_\_



⊕ TAPE NO. 301376 - 307 - 1 EXACTOGRAPH

DATE 12/11/75

JOB C6A1

SPADES SYSTEM

SHIP PRODUCTION AND CONTROL MODULE

ASSEMBLY INFORMATION

ASSEMBLY 302

PAGE 1.1\*

REV. 2

ASSEMBLY DESCRIPTION: INNERBOTTOM FR. 46-50 STBD. INCLUDING SHELL, FLOORS, GIRDERS AND TANK TOP

ASSEMBLY BOUNDARIES: VERTICAL (X) FROM B.L. TO SEAM F (J F)  
HORIZONTAL (Y) FROM C.L. TO SHELL STBD. (M)  
LONGITUDINAL (Z) FROM 1.0 FT. FWD. FR. 46 TO 1.25 FT. AFT FR. 50

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ASSEMBLY WEIGHT & C.G.: WEIGHT: 63.5 LT VCG: 2.87 FT. TCG: 17.67 FT. LCG: 1.33 FT. AFT FR. 48

SCHEDULED START DATE: 4/15/76

LIST OF SUB-ASSEMBLIES

SUB-ASSEMBLY NO.	SURFACE NAME	DESCRIPTION
302 - 1	M	SHELL STRAKES B & C
302 - 2	F 49000	FLOOR O.B. L.G. 6
302 - 2	F 49500	FLOOR O.B. L.G. 6
302 - 2	F 50000	FLOOR O.B. L.G. 6
302 - 3	D TT	TANK TOP

LIST OF APPLICABLE DRAWINGS FOR ASSEMBLY 302

LINE	DRWG. NO.	REV.	ISSUE DATE	TITLE
1	S11 - 3 - 3	4	4/15/75	FLOORS FR. 32 TO FR. 60
2	S11 - 4 - 2	3	3/21/75	T.T. PLTG. FR. 32 TO FR. 60
3	S11 - 1 - 2	2	1/21/75	SHELL PLTG. FR. 32 TO FR. 60.
4	S11 - 6 - 2	3	2/1/75	CVK AND LONGL. GDRS. FR. 32-60

DATE 12/11/75JOB C6A1

## SPADES SYSTEM

SHIP PRODUCTION AND CONTROL MODULE

'PAGE 2.1\*

REV. 2

## MATERIAL LIST FOR ASSEMBLY 302

## STEEL PLATES

LINE	STOCK NO.	GRADE	SIZE	QTY.	'X-REF.	TAPE / SK	PRC. TIME	STOR, LOC.
1		ABS -MILD	40 x 8 x .75	4'	NOTE 1	N/C-388001-1	125 MIN.	B-13
2		HY -80	37 X 9 X 1.00	2		SK 301376 -307-1	24 MIN.	C-7
3		ABS-MILD	40 x 8 x .5	1		SHEAR/OT		B-6
4		ABS -MILD	42 x 9 x .5	2	NOTE 2	N/C 311752- 1	109 MIN.	D-3

NOTES :

1. PROCESSING THIS TAPE WILL PRODUCE PIECES FOR ASSY(S) 304, 417.
2. THIS TAPE SHOULD HAVE ALREADY BEEN PROCESSED WITH ASSY. 301.

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## SPADES SYSTEM

SHIP PRODUCTION AND CONTROL MODULE

PAGE 3. 1\*

REV. 2

## STEEL SHAPES

LINE	STOCK NO.	GRADE	SIZE	LENGTH	QTY.	LINE NO. OF NESTED PIECES	STOR. LOC.
1		ABS - MILD	T9 x 4 x 21.30 <sup>#</sup>	40	16	2, 7, 9	M - 3
2		ABS - MILD	T9 x 4 x 21.30 <sup>#</sup>	40	4	2, 6, 10, 12	M - 3
3		ABS - MILD	I/T9 x4 x 17.50 <sup>#</sup>	26	1	8	M - 5
4		ABS - MILD	W/F10 X 10 X 77 <sup>#</sup>	40	2	37	M - 6
5		ABS - MILD	L6 x 4 x 13 <sup>#</sup>	40	4	4	M - 1
6		ABS - MILD	I12 x 5 x 35 <sup>#</sup>	40	1	1	M-17
7		ABS-MILD	T8 x 4 x 13 <sup>#</sup>	22	2	5	L -4

DATE 12/11/75  
JOB C6A1

SPADES SYSTEM  
SHIP PRODUCTION AND CONTROL MODULE

PAGE 4.1\*  
REV. 2

DETAIL LISTING OF REQUIRED PIEGES FOR ASSEMBLY 302  
PIECES PRODUCED THROOUGH N/C CUTTING

LINE	SUB-ASSY	DRWG; NO.	PC. NO.	DET.	STD. PC. NO.	MAT. REF.	QTY.	UN. WT.	ADD. PROCESS.	TEMPLATES
1	302-1	S11-1-2	17	5-B		2, 1-1	4		ROLL	388002 -402-1 388002 -403-1 388002 -404-1
2	302-3	S11-4-2	25	4-C		2, 1-4	2	7275#		
3	302-3	S11.4-2		-	5007		20			
4	302-2	s11-3-3	73	11-C	5220		2			

DATE 12/11/75  
JOB C6A1

S PADES SYSTEM  
SHIP PRODUCTION AND CONTROL MODULE

PAGE 5.1\*  
REV. 2

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PIECES PRODUCED THROUGH FLAME PLANER

LINE	SUB-ASSY	DRWG. NO:	PC: NO.	DET.	STD. PC: NO.	MAT. REF.	QTY.	UN. WT.	ADD.ROCESS,	TEMPLATES
1	302-1	S11.1-2	2	4 -A		2, 1-2	2	3488#		

DATE 12/11/75  
JOB C6A1

SPADES SYSTEM  
SHIP PRODUCTION AND CONTROL MODULE

PAGE 6.1 \*  
REV .

PIECES PRODUCED THROUGH OPTICAL CUTTING

IINE	SUB-ASSY	DRWG. NO:	PC. NO;	DET.	STD. PC. NO.	MAT. REF.	QTY.	UN. WT.	ADD; PROCESS.	TEMPLATES
*** NONE THIS ASSEMBLY * * *										

DATE 12/11/75JOB C6A1

S P A D E S   S Y S T E M  
SHIP PRODUCTION   ND CONTROL MODULE

PAGE 8.1\*

REV. 2

## PIECES PRODUCED FROM SHAPES

LINE	SUB-ASSY	DRWG.NO.	PC. MK.	DET.	STD. MK.	MAT.REF.	QTY.	UN.WT.	CUT LENGTH.	ADD.PR.	TEMPLATES
1	302-1	S11-1-2	57	5-A		3.1-6	1	271#	7-9-3(F)		
2	302-1	S11-1-2	58	5-A		3.1-1	20	261#	12-3-4		
3	302-1	S11-1-2	59	5-A		3.1-4	2	2811#	36-6-0(E)		
4	302-1	S11-1-2	60	5-A		3.1-5	4	390#	30-0-0	FRMBND	384005-402-2
5	302-3	S11-4-2	25	4-C		3.1-7	2	469#	36-1-0(F)		385005-402-2

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S P A D E S   S Y S T E M  
SHIP PRODUCTION AND CONTROL MODULE

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REV. 2

## PIECES PRODUCED THROUGH SHEARING

LINE	SUB-ASSY	DRWG.NO.	PC. NO.	DET.	STD. PC. NO.	MAT. REF.	QTY.	UN.WT.	ADD. PROCESS.	TEMPLATES
1	302-3	S11-4-2	77	2-C		2.1-3	1	653#		



- b) Through the use of 'MANFAID' (frame bending), all shapes, whether straight or curved, will be identified and allocated to the proper assembly. The Frame Bending Program will be modified to easily do that for all flat surfaces.
- c) Through the use of the Ship Production and Control (SPAC) Module, the loft will input to the System all the miscellaneous pieces not otherwise identified.

# ' S P A D E S '      S Y S T E M

## ENGINEERING    DETAILING    MODULE

### Preliminary Description

( DEMO )

### ' OBJECTIVES

The main purpose of this module is to utilize the time and effort spent during the detail design phase for numerical description of the ship structure. During this phase, all structural details are defined; and if these definitions can be recorded on the data base, interpretation of the drawing and the possibility of errors downstream during part generation can be greatly reduced. Greatly expanded data base loading capabilities will provide information over and above the geometrical part generation requirements which can be used by the planning and control module or other ship's systems.

As the volume of information on the data base increases and the data base becomes more comprehensive, verification of loaded data becomes more and more difficult. The quickest way of verification is by drawing. Therefore, a simple and easy way of accessing the data base with a few commands is needed to automatically output all loaded data of a particular surface into a composite drawing.

If this drawing capability is achieved, only a few options are needed to extract partial drawings for all kinds of purposes. Structural drawings can be complete with the exception of lettering and dimensioning. Background drawings for arrangements and composites can be produced with just a few commands.

### PREREQUISITES

In order to make this module an efficient tool for detailing, the loading capabilities of the data base will be expanded. The 'HULLLOAD' Module will be capable of loading traces and details in transverse, plan and elevation views. Additional information on all surfaces will include:

- a) Stiffeners and their end connections
- b) Seams and plate thickness associated
- c) Brackets and chocks
- d) All access holes, including face bars
- e) Inside contours, as defined by web frames.

All through members affecting other surfaces must be handled by 'HULLLOAD' .  
Local details will be defined by 'DEMO'.

## OPERATING PROCEDURE

Although the module's primary task is to aid in loading the data base, direct loading capability is not conceived. The actual loading of the data base is reserved for the group of people responsible for loading the data base through 'HULLLOAD'. This is to preserve the integrity of the data base by concentrating the responsibility onto one person, or one group of people. However, to avoid having the 'HULLLOAD' people recode all the definitions, Module 'HULLLOAD' will have the capability of executing the same input decks, ignoring irrelevant commands, but executing and loading the detail specifications.

The application of the module within the ship design effort is seen as follows:

1. Fairing and loading of the major structure through 'HULLLOAD'.
2. Extract a drawing of the surface containing outlines and through members through 'DEMO'.
3. Load repetitive patterns of stiffeners and seams through 'HULLLOAD'.
4. Extract a new drawing through 'DEMO' containing all loaded details.
5. With 'DEMO' , add and modify details of stiffeners, seams, holes and brackets, resulting in:
  - . A new drawing, complete with the exception of lettering and dimensioning
  - . An input deck defining the details executable by 'HULLLOAD'
  - . An entry in a data base record which contains all input decks that are generated by 'DEMO' and must be executed by 'HULLLOAD'
6. When the design is completed, control is transferred to 'HULLLOAD'. The input deck is executed, loading the details. The entry of the final step above is deleted.
7. Revisions:
  - a) If the drawing is not released as yet, the revision may be added to the 'DEMO' input deck executing '5' and '6'.
  - b) If the drawing is released and lettering and dimensioning has been added, revisions are effected through 'HULLLOAD' only.
8. After the structural details have been loaded, drawings for other disciplines such as arrangements and composites may be called.

INFORMATION   DEFINED   BY   'DEMO'

Only local details are defined through 'DEMO' . Details are defined as follows:

1. Stiffeners:      Symbolic name            S   ABC   P/S  
                         Contour definition  
                         Shape code number  
                         Orientation (near side or far side)  
                         End connections (lap, snipes, knuckles).
2. Seams:           Symbolic name            J   ABC   P/S  
                         contour definition  
                         Welding detail (bevel and gap)  
                         Thickness on both sides.
3. Holes:            Symbolic name            H   123   P/S  
                         Contour definition  
                         Thickness, width and off set of face bar.
4. Brackets:        Symbolic name            B   123   P/S  
                         Contour definition or standard detail identification  
                         Thickness  
                         Width and thickness of flange.
5. Inner Lines:      Accessible only as a contour  
                         Identified by 'LNNL'  
                         Contour definition  
                         Width and thickness of face bar.

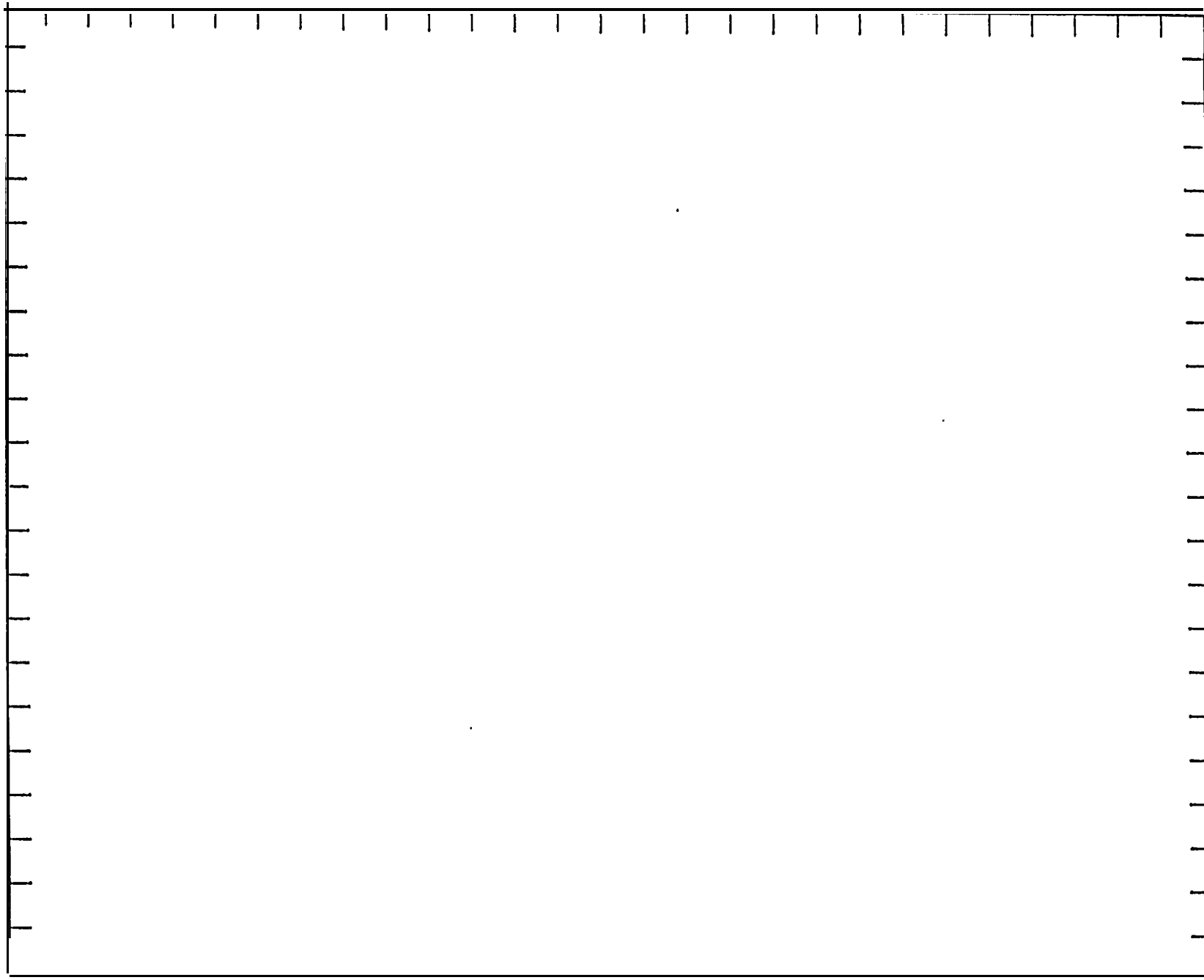
## PROGRAM CAPABILITIES

1. options with automatic drawing Of data base contents:
  - a) Scales
  - b) Windowing
  - c) With or without shapes ('T', 'L', etc. )
  - d) With or without cut-outs and snipes
  - e) With or without stiffeners and seams on the surface
  - f) Include background frame or deck
  - g) Pen selection for turret machines
  - h) Line selections of different types of dashed lines.
2. .Automatically included as drawing standard:
  - a) A standard grid surrounding the entire drawing
  - b) Center line and/or base line, if part of the drawing.
3. Programming capabilities and language as close to 'PARTGEN' as possible, so that people programming 'PARTGEN' and 'DEMO' are interchangeable. . All 'PARTGEN' tools such as Math, Contours, Symbolic Calls, Loops and Reps will be available.
4. Added Commands for detail definition:
  - a) STIF
  - b) SEAM
  - c) HOLD
  - d) BRKT
  - e) INNL
5. Looping capability:

Programming of similar surfaces by modification to typical surface such that only changes have to be redefined.

Fig. 1

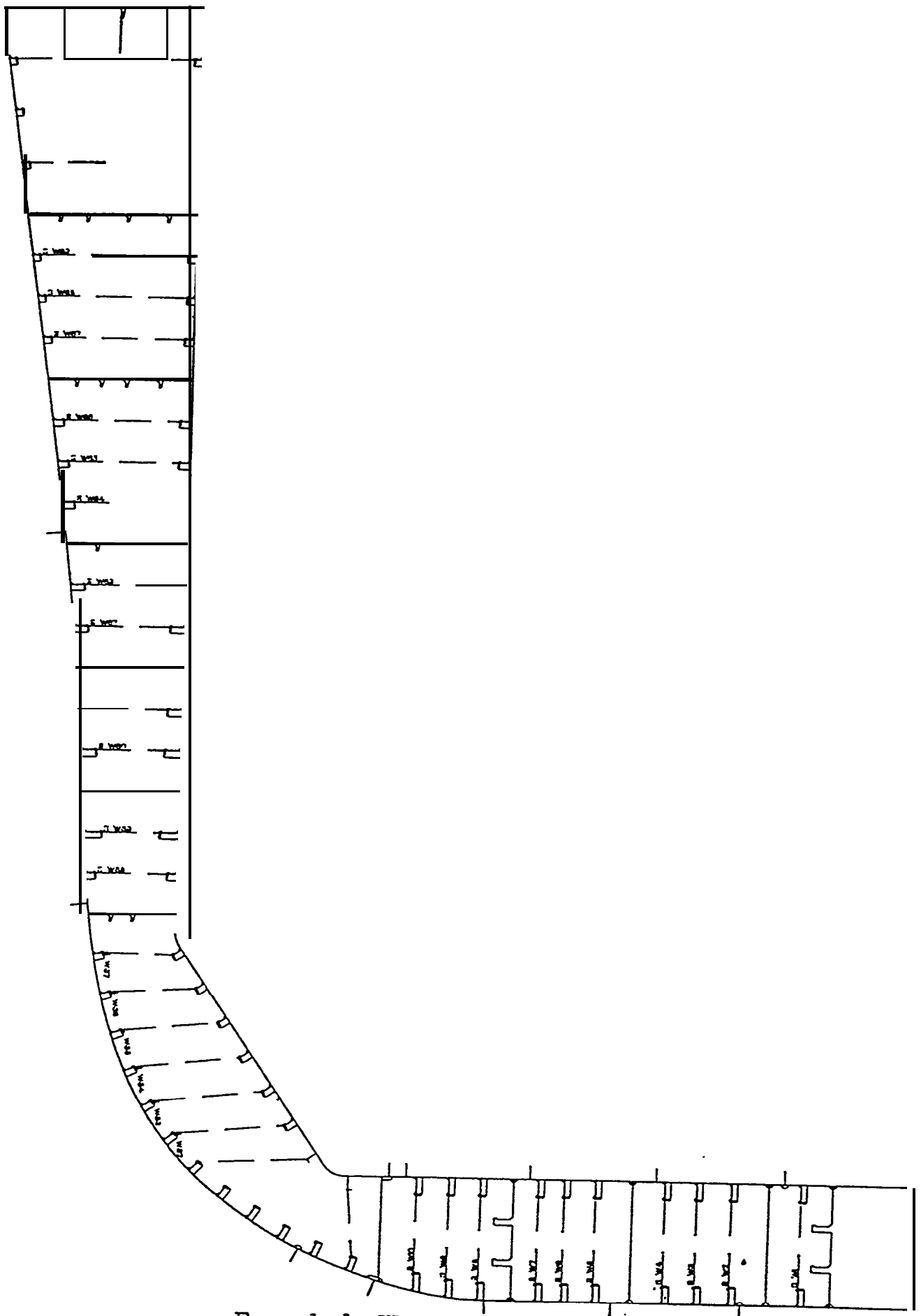
120



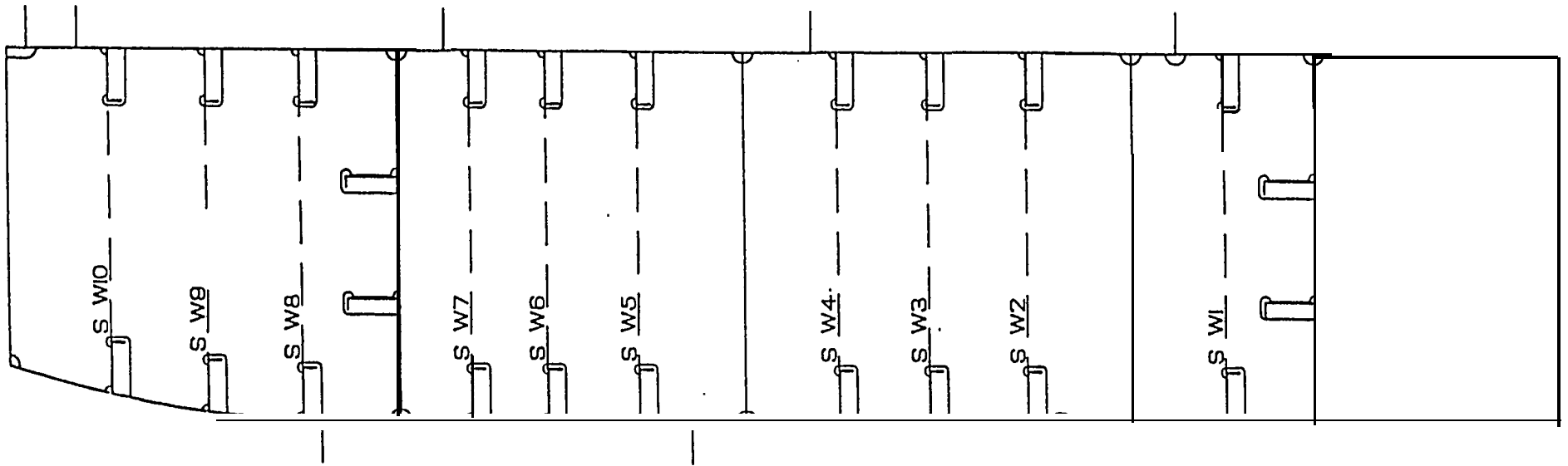
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TAPE NO. 203002 - 1

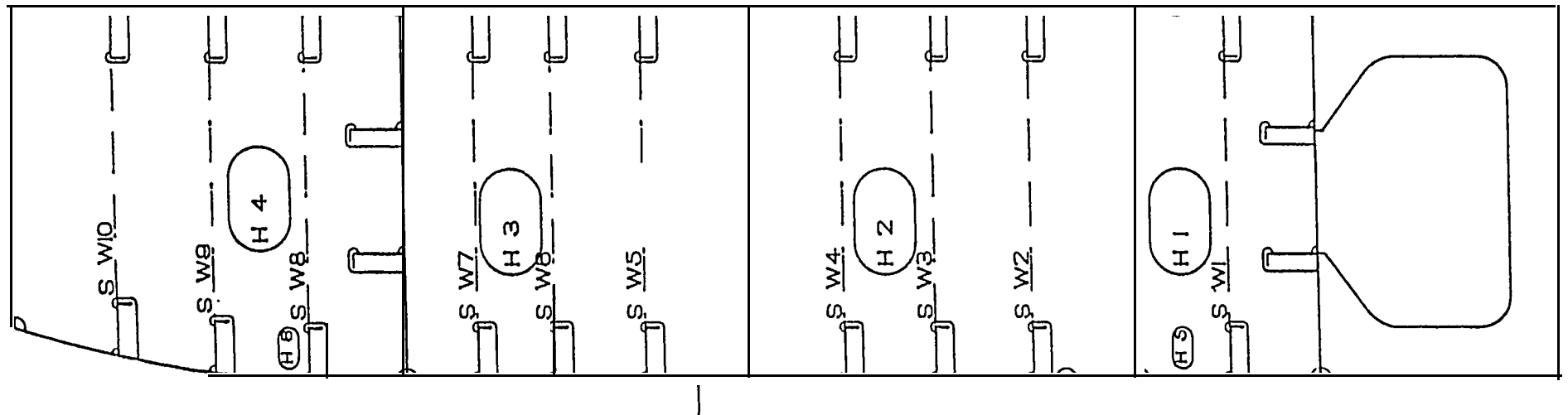
Standard Grid for All Drawings



Example 1: Webframe 52  
Drawing after 'HULLLOAD' only

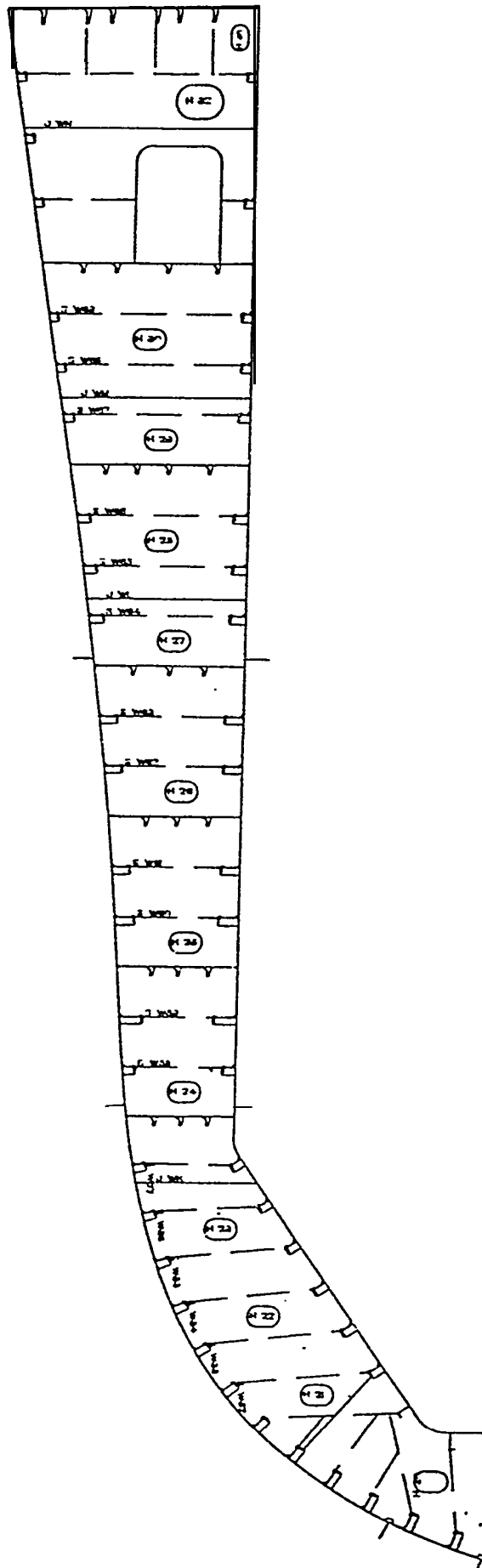


Example 1: Floor 52  
Drawing after 'HULLLOAD' only

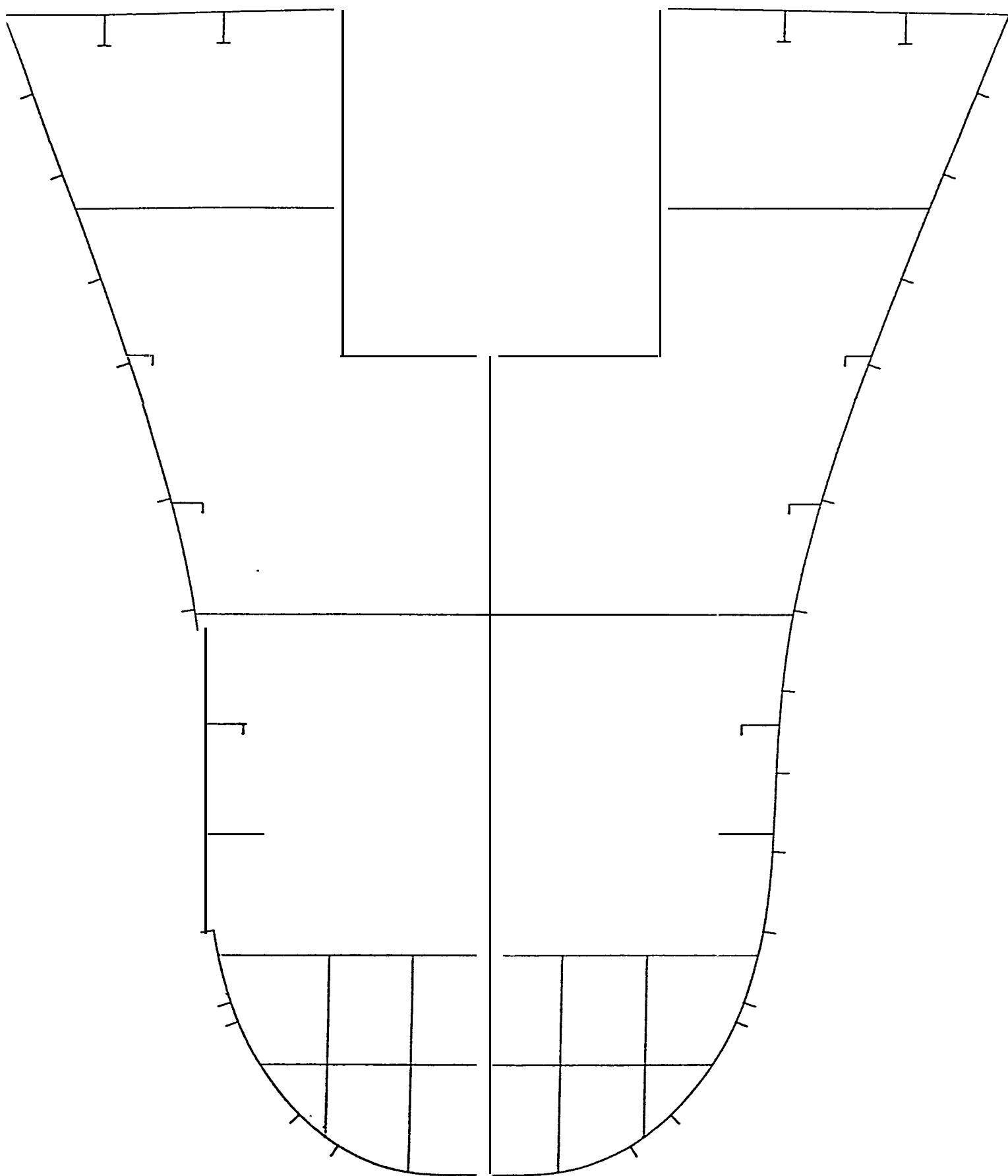


Example 1: Floor 52  
Drawing after detailing by 'DEMO'.

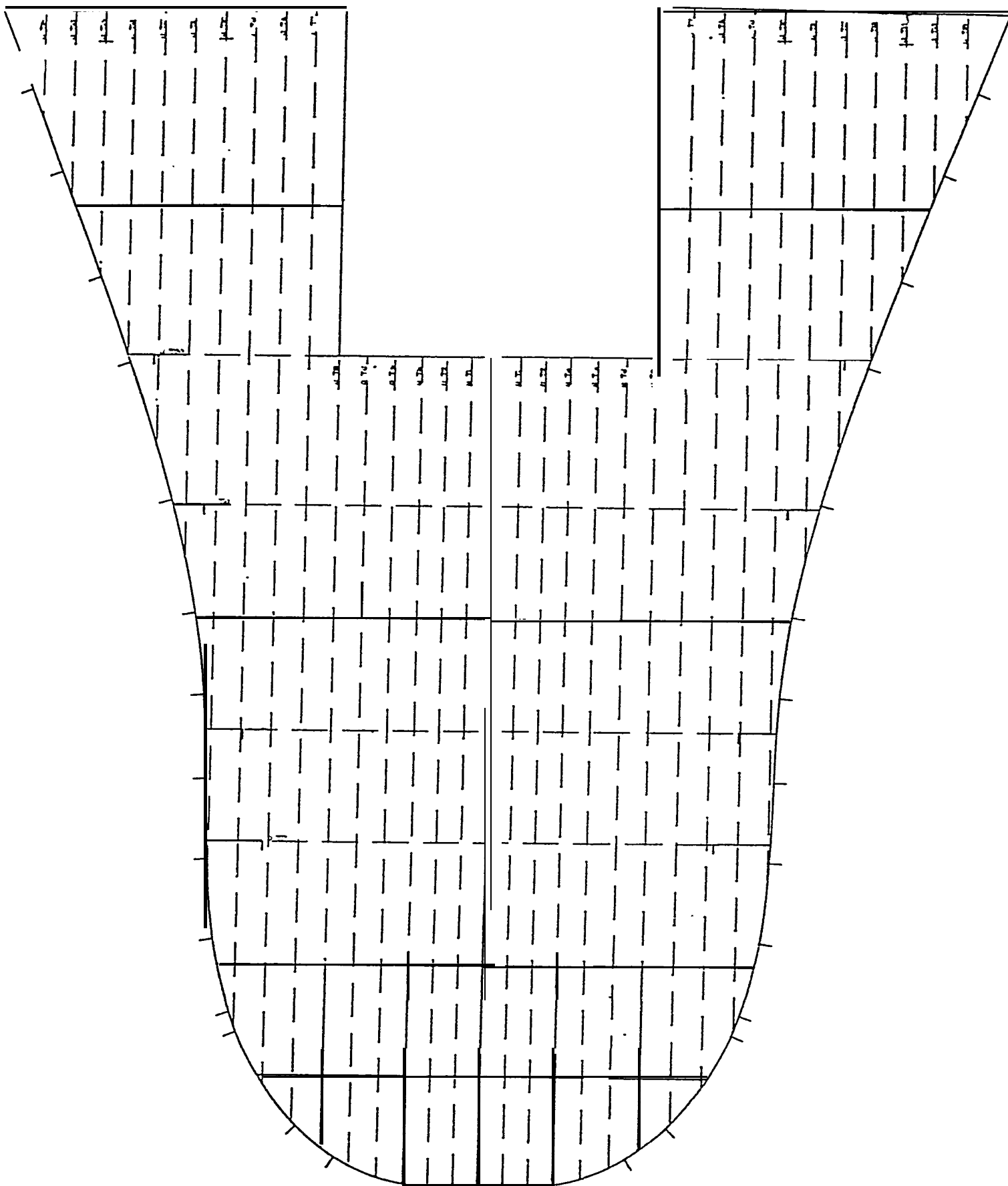




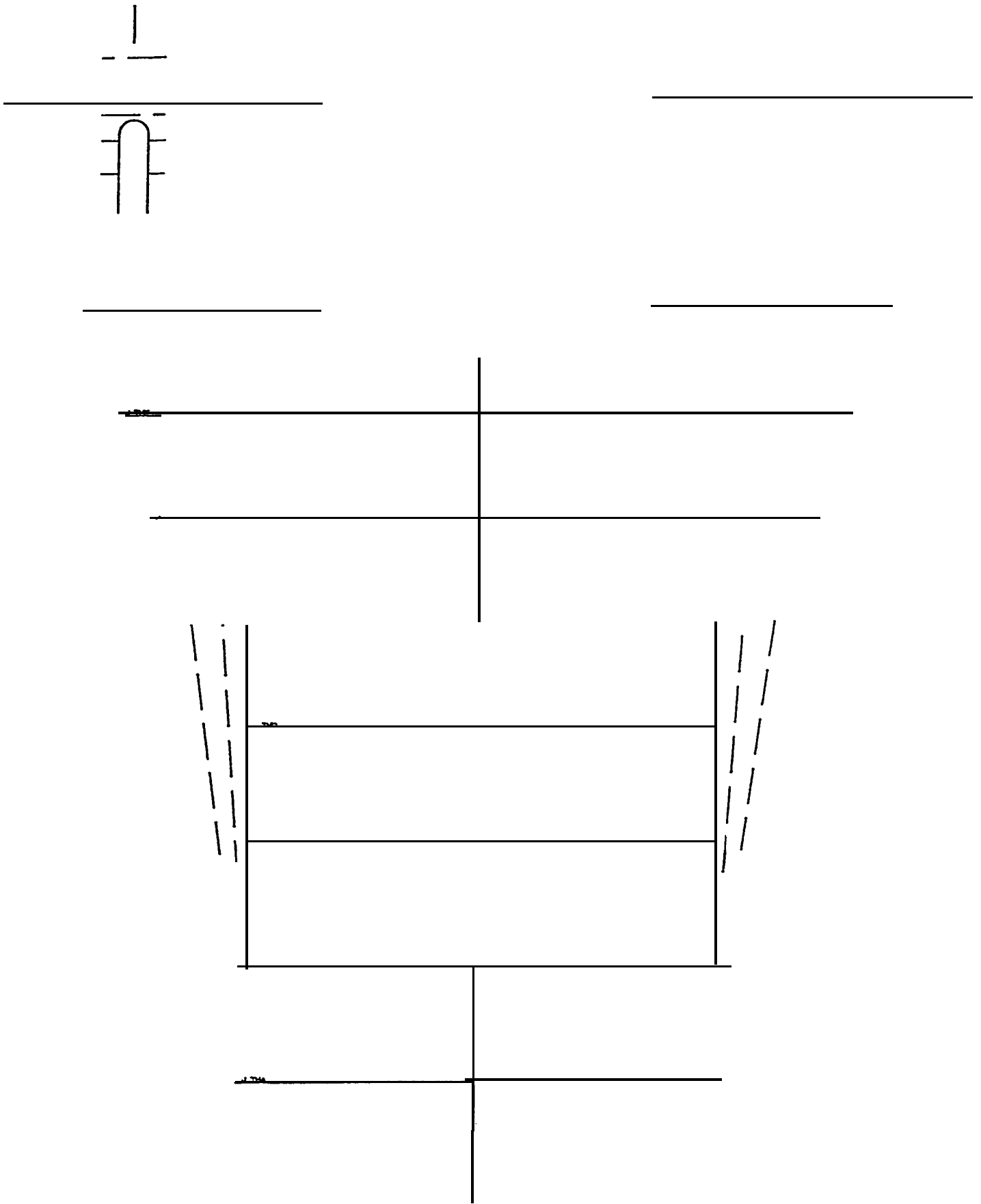
Example 1 . Window of Webframe 52  
after detailing by 'DEMO'



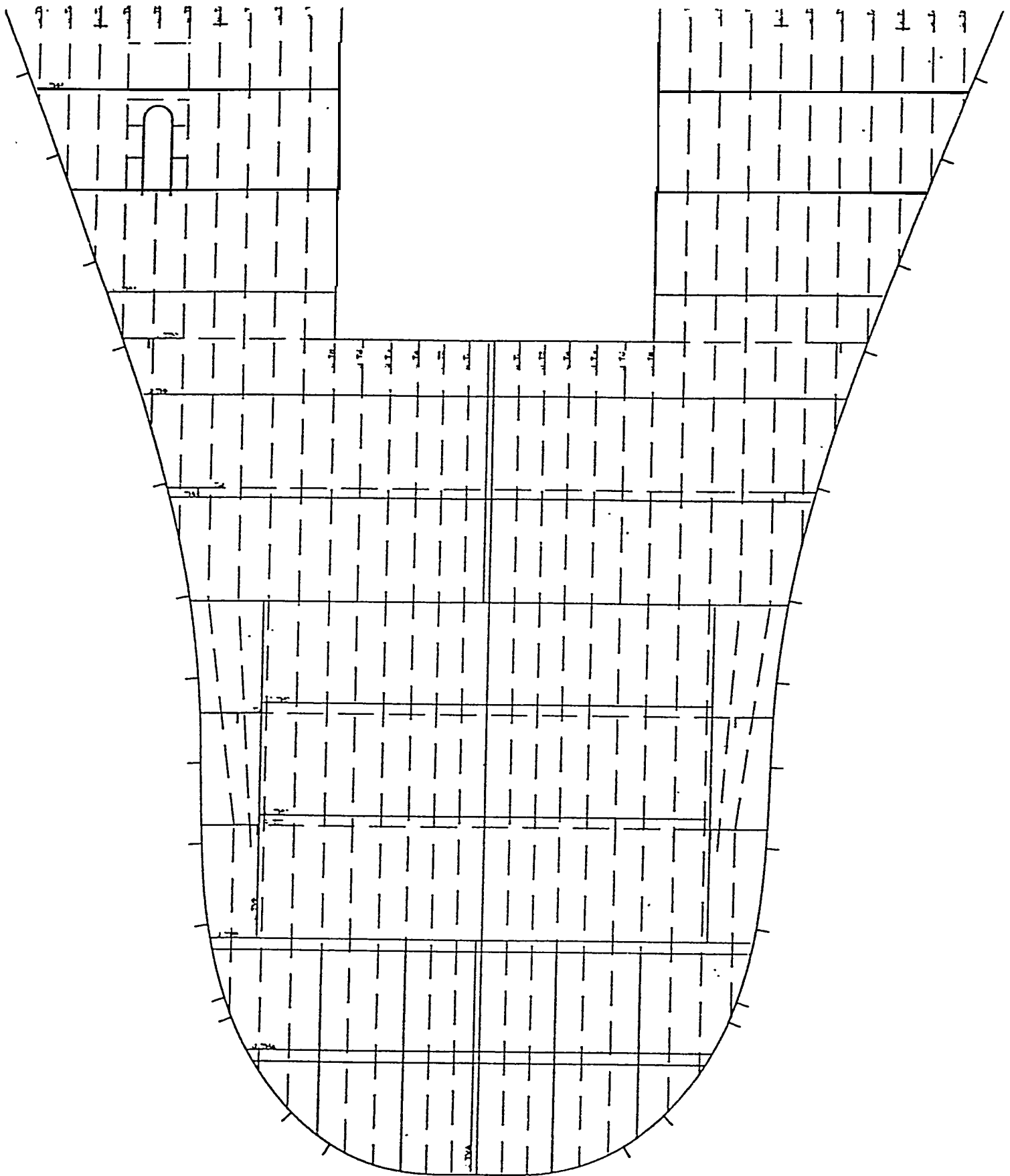
Example 2: Bulkhead 31  
 Drawing of major structure after 'HULLLOAD'  
 124 only.



Example 2: Bulkhead 31  
 Drawing of loaded details after 'HULLLOAD'



Example 2: Bulkhead 31  
Details programmed in 'DEMO'



Example 2: Bulkhead 31  
Final drawing after detailing by 'DEMO'

# ' S P A D E S '      S Y S T E M

## PIPE   LENGTH   AND   END-CUTS   PROGRAM

( P L E C )

### PROGRAM   DESCRIPTION

#### 1. PROGRAM   CAPABILITIES

The Pipe Length and End- Cuts (PLEC) Development Program allows the user to simply define a complex three-dimensional pipe structure and extract for each member all data necessary for its fabrication.

It is designed to accurately determine the length and shape of end-cuts of a straight cylinder (pipe) terminating at both ends into or penetrating through one or more of the following surfaces:

- Straight cylinder with identical or different diameter and with or without axial eccentricity.
- Curved cylinder, as in above.
- Cone, with or without axial eccentricity
- Plane inclined at any angle .
- Sphere with or without eccentricity.

Within this context, the term 'eccentricity' is used to indicate the case when the two axes are not contained in the same plane. For the sphere cylinder intersection, eccentricity means that the center of the sphere does not lay on the axis of the cylinder.

In the generation of data, allowance will be made to include the slots needed for through brackets or collars.

The data generated by the program can be outputted in any one of the formats described below, subject to the following limitations:

- Tabulation Format. This option is always available and allows in all cases the manual plotting of templates or layout on the surfaces.

- Template Format. This option, subject to the availability of a drafting machine, is always available, except in the case of the penetration cut on a sphere or curved cylinder, since the development into a flat template is possible.

- N/C Paper Tape. This option is available for all cases compatible with availability and capability of the N/C cutting machine.

## 2. INPUT HANDLING

As for all modules of the 'SPADES' System, all input will be permanently stored in the data base, and the standard 'SPADES' update facility is available for changes or revisions.

The input data required by the 'PLEC' Program can be divided in two categories:

### a. Definition Input

This type of input is used to define a three-dimensional structure.

The definition includes the three-dimensional location of all joints and the characteristics of any member between any two joints.

The input language is such that location of all joints can be done utilizing dimensions, angles and units of measure (including metric) as given in the design drawings. As an aid to check the validity of the input data, the program will generate a tabulation of the processed

data; and if a drafting machine is available, a drawing at the appropriate scale of the orthogonal views of the structure.

b. Execution Input

This type of input causes the program to generate the appropriate form of output needed to fabricate any member previously defined through definition input or whose definition is contained therein.

3. OUTPUT HANDLING

All output tapes (drafting or cutting machine) and tabulations will be stored permanently in the data base for back-up and later recall similarly to all 'SPADES' modules.

Revision control will be active for all outputs in order to ensure at all times the use of the correct tabulation, template or tape. In addition, the program will generate a printout containing all pertinent messages to the user, such as diagnostic error code and information messages relating to:

- Input data manuscript number and revision
- Output generated ID. number and revision
- Minimum cut-length of pipe stock needed
- Distance between bases (reference lines) for machine indexing or template application
- Processing time required to cut the pipe in the cutting machine
- Other erection information such as 'crawl' dimensions and angles.

The weight of each member will be computed and added to the member sketch;

The output data will be, at the user's option, in one or more of the following formats:

a. Tabulation

For those users without a drafting machine or a numerical control



pipe cutting machine, this output option gives all numerical data to make wrap-around templates, cut the pipe to correct length, and get the desired bevel.

**b. Templates by Drafting Machine**

This form of output will generate a paper tape for a drafting machine to draw the necessary wrap-around templates.

The end-cut templates for pipe members will be of the following types:

- Outside wrap-around with inside layout
- Outside wrap-around with both inside and outside layout. Either the inside or outside layout will be modified to reflect the required bevel, if any.
- Either of the above two developed on half thickness diameter rather than wrap-around for application prior to rolling of plate.

Any of the above can be set as a default option specified by the user.

The end - cut templates for beam members will contain the cut contours for both web and flange(s).

Each template will be automatically sectionalized to suit the size of the drafting machine available to the user and will contain appropriate reference lines for longitudinal and angular orientation of the template, Length of pipe and distance between reference markings will also be indicated on the templates.

A dimensioned sketch of the member will also be generated through the drafting machine, indicating as requested in each case, long/short to long/short length and length between reference markings. Length of transition and thickness changes will also be indicated.

c. Paper Tape for N/C Pipe Cutting Machine

This option will allow the user to generate a paper tape to cut the pipe with the desired bevel under numerical control. The tape will be totally compatible with the cutting machine and will allow as automated an operation as the machine is capable of.

The user will be responsible for furnishing to 'Cali & Associates, Inc.' all necessary and applicable information related to machine capability and tape format required by the N/C director.

Since 'PLEC' will be integrated with the 'SPADES' System, all general management and control features will be implemented.

4. ADDITIONAL FEATURES EFFECTED BY OTHER 'SPADES' MODULES

a. 'PARTGEN' Modification

Modify 'PARTGEN' to access the records loaded by 'PLEC' in order to allow easy development of any pipe related structure, whether internal or external to the pipe. Additional comamands will be added as needed for this purpose.

b. 'HULLCAL' Modification

Modify 'HULLCAL' to access the records loaded by 'PLEC' containing the geometrical description of the pipe structure. Add routines to 'HULLCAL' to handle the specific geometry of the pipe structure for inclusion in the calculations of all applicable 'HULLCAL' sub-programs.

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